

WHAT IS CLAIMED IS:

1 1. A method for converting video data format from interlaced scan rate to
2 progressive scan rate, said method comprising of a perceptual model to determine
3 membership probabilities of field samples (pixels) with regard to a plurality of image
4 components of a field, said determination prioritizes the contributions from said image
5 components, where the said image components are a static image component, a texture image
6 component, and a motion image component.

1 2. The method of claim 1, where the interpolated samples of the final progressive
2 frame is obtained by summing the modulated or adjusted versions of a plurality of image
3 components.

1 3. The method of claim 2, where a current field, a past field and a future field are
2 all partitioned into blocks of samples (pixels), and the image components are computed for
3 samples of a block of the said current field based on block-based and sub-block-based
4 perceptual parameters obtained from samples of the said current field, said past field, and said
5 future field.

1 4. The method of claim 3, where adjustment of the static image component is
2 comprised of reducing the said component by a modulated version of the said component,
3 where the said modulation factor is Ra and is comprised of scaling an aed factor by BAI , the
4 said aed is derived by computing the average energy of the difference between a block in
5 future field and a prediction of the said block in past field, and further, the said BAI is
6 obtained by computing the image difficulty of a block in current field.

1 5. The method of claim 4, where the modulation factor Ra is incremented by a
2 term comprised of modulating Ra by a second modulation factor RSa , the said RSa is
3 comprised of scaling an $aeds$ factor by $SVAI$, the said $aeds$ is derived by computing the
4 average energy of the difference between a sub-block in future field and a prediction of the
5 said sub-block in past field, the said sub-blocks being subset of blocks of claim 4 or have
6 some overlapping pixels, and further, the said $SVAI$ is obtained by computing the average
7 vertical image difficulty of the said sub-block in future field and a third sub-block in past

8 field, the third sub-block in past field having the same coordinates as the said sub-block in
9 future field.

1 6. The method of claims 4 and 5 where both the block and sub-block predictions
2 use the same motion information.

1 7. The method of claim 3, where the static image component is modulated by a
2 factor Rm , said Rm is comprised of scaling the aed factor of claim 4 by $aed0$ where the said
3 $aed0$ is derived by computing the average energy of the difference between a block in future
4 field and a corresponding block in past field, the said block in past field having the same
5 coordinates as the said block in future field.

1 8. The method of claims 4, 5, 6 and 7 where the same process is used for texture
2 image component.

1 9. The method of claims 2, 3, 4, 5, and 7, when the nominal values of Ra and aed
2 are small, only contributions from static image component and motion image component are
3 used.

1 10. The method of claim 9, when a small amount of motion for a block of samples
2 is detected, the interpolated pixel is a sum of a modulated motion image component and an
3 adjusted static image component, the said adjustment comprised of reducing the static image
4 component by a modulated version of the static image component, the said modulation factor
5 is Ra as described in claim 4.

1 11. The method of claim 9, when significant amount of motion for a block of
2 samples is detected, the interpolated pixel is a sum of a modulated static image component
3 and an adjusted motion image component, the said adjustment is comprised of reducing the
4 motion image component by a modulated motion image component, the said modulating
5 factor being Rm , the same as the modulating factor derived in claim 7 for the static image
6 component.

1 12. The method of claim 3, where the static image component is modulated by a
2 factor $T1$, said $T1$ is comprised of adding an ascending term and a descending term, said

3 ascending term is further comprised of modulating Rm by an increasing function $Af(Va)$,
4 said Rm as described in claim 7, said increasing function increases as the amount of block
5 motion Va increases, and the said descending term is comprised of modulating the adjustment
6 factor $(1 - Ra)$ by a decreasing function $Df(Va)$, where the said Ra is described in claim 4,
7 and the said decreasing function decreases as the amount of block motion Va increases.

1 13. The method of claims 10 and 12 with Ra being replaced by $Ra \times (1 + RSa)$,
2 where RSa is described in claim 5.

1 14. The method of claims 9 and 12, when moderate amount of motion for a block
2 of samples is detected, the interpolated pixel is sum of a modulated static image component
3 and an adjusted motion image component, the said adjustment is comprised of reducing the
4 motion image component by a modulated motion image component, the said modulating
5 factors being Tl .

1 15. The method of claim 3, when the nominal values of Ra and aed are large, only
2 contributions from texture image component and motion image component are used, the said
3 values of Ra and aed are defined in claim 4.

1 16. The method of claim 15, when a small amount of motion for a block of
2 samples is detected, the said block has a dominant texture image component.

1 17. The method of claim 16, where the interpolated pixel is a sum of a modulated
2 motion image component and an adjusted texture image component, the said adjustment
3 comprised of reducing the texture image component by a modulated version of the texture
4 image component, the said modulation factors are $Ra \times (1 + RSa)$, where Ra is defined in
5 claim 4 and RSa is defined in claim 5.

1 18. The method of claim 15, when significant amount of motion for a block of
2 samples is detected, the interpolated pixel is a sum of a modulated texture image component
3 and an adjusted motion image component, the said modulation factor is Rm as defined in
4 claim 7, and further, the said adjustment is comprised of reducing the motion image
5 component by a modulated motion image component, the said modulating factor being Rm .

1 19. The method of claim 15, where the texture image component is modulated by
2 a factor Ts , said Ts is comprised of adding an ascending term and a descending term, said
3 ascending term is defined in claim 12, and the said descending term is comprised of
4 modulating the adjustment factor $(1 - Ra \times (1 + RSa))$ by a decreasing function $Df(Va)$,
5 where $Df(Va)$ is described in claim 12 and RSa is defined in claim 5.

1 20. The method of claims 17 and 19 where factor $Ra \times (1 + RSa)$ is replaced by
2 Ra .

1 21. The method of claims 15 and 19, when moderate amount of motion for a block
2 of samples is detected, the interpolated pixel is sum of a modulated texture image component
3 and an adjusted motion image component, the said modulating factor is Ts and further, the
4 said adjustment is comprised of reducing the motion image component by a modulated
5 motion image component, the said modulating factor being Ts .

1 22. The method of claim 3, when the nominal value of Ra is large and the nominal
2 value of aed is small or when the nominal value of Ra is small and the nominal value of aed
3 is large, the said values of Ra and aed as defined in claim 4, and further, the amount of
4 motion is small for a block of samples, the interpolated pixel is sum of an adjusted spatial
5 image component and a modulated motion image component, said adjustment is comprised
6 of reducing the spatial image component by a modulated version of the spatial image
7 component, said modulation factor is $Ra \times (1 + RSa)$, said spatial image component is further
8 comprised of summing an adjusted static image component and a modulated texture image
9 component, said adjustment is comprised of reducing the static image component by a
10 modulated version of the static image component, said modulation factor is RSa , the said RSa
11 is defined in claim 5.

1 23. The method of claim 3, when the nominal value of Ra is large and the nominal
2 value of aed is small or when the nominal value of Ra is small and the nominal value of aed
3 is large, the said values of Ra and aed as defined in claim 4, and further, the amount of
4 motion is significant for a block of samples, the interpolated pixel is sum of a modulated
5 spatial image component and an adjusted motion image component, said adjustment is
6 comprised of reducing the motion image component by a modulated version of the motion

7 image component, said modulation factor is Rm , said spatial image component is further
8 comprised of summing an adjusted static image component and a modulated texture image
9 component, said adjustment is comprised of reducing the static image component by a
10 modulated version of the static image component, said modulation factor is RSa , the said RSa
11 is defined in claim 5 and the said Rm is defined in claim 7.

1 24. The method of claim 3, when the nominal value of Ra is large and the nominal
2 value of aed is small or when the nominal value of Ra is small and the nominal value of aed
3 is large, the said values of Ra and aed as defined in claim 4, and further, the amount of
4 motion is moderate for a block of samples, the interpolated pixel is sum of a modulated
5 spatial image component and an adjusted motion image component, said adjustment is
6 comprised of reducing the motion image component by a modulated version of the motion
7 image component, said modulation factors are Ts , and further, the said spatial image
8 component is sum of a modulated texture image component and an adjusted static image
9 component, said adjustment is comprised of reducing the static image component by a
10 modulated version of the static image component, said modulation factors are RSa , where the
11 said Ts is defined in claim 19 and said RSa is defined in claim 5.

1 25. The method of claim 22 where $Ra \times (1 + RSa)$ is replaced by Ra .

1 26. The method of claim 24 where Ts is replaced by $T1$, said $T1$ is defined in
2 claim 12.

1 27. The method of claim 3 where a ratio Ro is obtained for a block of current
2 field, said ratio is comprised of adding vertical ratio Rv and horizontal ratio Rh , said vertical
3 ratio is obtained from scaling a vertical block activity indicator by BAI , and further, said
4 horizontal ratio is obtained from scaling a horizontal block activity indicator by BAI , where
5 BAI is defined in claim 4.

1 28. The method of claim 27, when the magnitude of Ro is small for a block of
2 samples in the current field, and further, the amount of motion is not small for the said block,
3 the said block is declared to have moving edges.

1 29. The condition in claim 28 where only contributions from the texture image
2 component and motion image component are used.

1 30. The method of claim 29, when significant amount of motion for a block of
2 samples is detected, the interpolated pixel is a sum of a modulated texture image component
3 and an adjusted motion image component, the said modulation factor is Rm as defined in
4 claim 7, and further, the said adjustment is comprised of reducing the motion image
5 component by a modulated version of the motion image component, the said modulating
6 factor being Rm .

1 31. The method of claim 29, when moderate amount of motion for a block of
2 samples is detected, the interpolated pixel is sum of a modulated texture image component
3 and an adjusted motion image component, the said modulating factor is Ts , and further, the
4 said adjustment is comprised of reducing the motion image component by a modulated
5 version of the motion image component, the said modulating factor being Ts , said Ts is
6 defined in claim 19.

1 32. The method in claim 31 where Ts is replaced by $T1$, said $T1$ is defined in
2 claim 12.

1 33. The method of claim 1, where the perceptual model is assisted by a dual-stage
2 motion compensation unit.

1 34. A method for converting video data from interlaced format to progressive
2 format, comprising:

3 determining a probability of a first image component of a field, wherein the
4 determination assigns a priority to the first image component; and
5 determining a probability of a second image component of a field, where the
6 determination assigns a priority to the second image component.

1 35. The method as recited in claim 34, further comprising:
2 modulating a first image component to produce a first modulated image component;

3 modulating a second image component to produce a second modulated image
4 component;
5 summing the first modulated image component and the second modulated image
6 component; and
7 producing a progressive frame based on the sum of the first modulated image
8 component and the second modulated image component.

1 36. The method as recited in claim 34, further comprising:
2 partitioning a first field to produce a first block of samples;
3 partitioning a second field to produce a second block of samples;
4 determining a first image component for the first block of samples; and
5 determining a second image component based on the second block of samples.

1 37. The method as recited in claim 36, further including:
2 modulating the first image component based on an average energy ("aed") of a
3 difference between a block in a future field and a prediction of the block in a
4 past field scaled by an image difficulty of a block ("BAI") in the current field.

1 38. The method of claim 37, further comprising:
2 computing the average energy of the differences between a sub-block in a future
3 field and a prediction of the sub-block in a past field;
4 computing the average vertical image difficulty of the sub-block in the future field
5 and the sub-block in past field, the sub-block in past field having the same
6 coordinates as the sub-block in future field;
7 modulating the first image component based on the average energy of the
8 differences between a sub-block in the future field and a prediction of the sub-
9 block in a past field; and
10 modulating the first image component based on the average vertical image
11 difficulty of the sub-block in the future field and the sub-block in past field,
12 the sub-block in past field having the same coordinates as the sub-block in
13 future field.

1 39. The method of claim 37, further comprising:
2 predicting a block based upon a first set of motion information; and

3 predicting a sub-block based on the first set of motion information.

1 40. The method of claim 36, further including:

2 computing the average energy (“aed0”) of the difference between a block in a future
3 field and a block in a past field, the block in the future field having a first set
4 of coordinates, the block in the past field having a second set of coordinates,
5 wherein the first set of coordinates and the second set of coordinates are
6 substantially equal; and

7 modulating the first image component based on the average energy of the difference
8 between the block in the future field and the block in the past field.

1 41. The method as recited in claim 36, further including:

2 modulating the second image component based on an average energy (“aed”) of a
3 difference between a block in a future field and a prediction of the block in a
4 past field scaled by an image difficulty of a block (“BAI”) in the current field.

1 42. The method of claim 41, further including:

2 scaling *aed* by *BAI* to produce a modulation factor (“Ra”); and

3 if *Ra* and *aed* are larger than a threshold value, further including;

4 modulating the second image component based on an average energy (“aed”) of a
5 difference between a block in a future field and a prediction of the block in a
6 past field scaled by an image difficulty of a block (“BAI”) in the current field.

1 43. The method as recited in claim 42, further comprising:

2 computing a motion for a block of samples, wherein an interpolated pixel is

3 produced if the motion of a block of samples is less than a threshold value;

4 modulating a first image component;

5 adjusting a second image component; and

6 summing the modulated first motion image component and the adjusted second image
7 component to produce an interpolated pixel.

1 44. The method of claim 42, further comprising:
2 computing the amount of motion for a block of samples, wherein if the amount of
3 motion for the block of samples is greater than a threshold value, an
4 interpolated pixel is produced;
5 modulating a first image component;
6 adjusting a second image component, further including;
7 reducing a second image component by a factor, wherein the factor ("Rm") is
8 computed by scaling *aed* by *aed0*.

1 45. The method as recited in claim 36, further comprising:
2 modulating the first image component, including:

3 summing an ascending term, including
4 increasing a first modulation factor by a function increasing as the
5 motion of the block increases; and
6 summing a descending term, including:
7 decreasing a second modulation factor by a function decreasing as the
8 motion of the block increases.

1 46. A computer program product for converting video data from interlaced format
2 to progressive format, comprising:

3 a set of instructions configured to determine a probability of a first image component
4 of a field, wherein the determination assigns a priority to the first image
5 component; and
6 a set of instructions configured to determine a probability of a second image
7 component of a field, where the determination assigns a priority to the second
8 image component.

1 47. The computer program product as recited in claim 46, further comprising:
2 a set of instructions configured to modulate a first image component to produce a first
3 modulated image component;
4 a set of instructions configured to modulate a second image component to produce a
5 second modulated image component;

6 a set of instructions configured to produce a progressive frame based on the sum of
7 the first modulated image component and the second modulated image
8 component.

1 48. The computer program product as recited in claim 46, further comprising:
2 a set of instructions configured to partition a first field to produce a first block of
3 samples;
4 a set of instructions configured to partition a second field to produce a second block
5 of samples;
6 a set of instructions configured to determine a first image component for the first
7 block of samples; and
8 a set of instructions configured to determine a second image component based on the
H9 second block of samples.

H10 49. The computer program product as recited in claim 48, further comprising:
H11 a set of instructions configured to modulate the first image component based on an
H12 average energy ("aed") of a difference between a block in a future field and a
H13 prediction of the block in a past field scaled by an image difficulty of a block
H14 ("BAI") in the current field.

H15 50. The computer program product as recited in claim 49, further comprising:
H16 a set of instructions configured to compute the average energy of the differences
H17 between a sub-block in a future field and a prediction of the sub-block in a
H18 past field;
H19 a set of instructions configured to compute the average vertical image difficulty of
H20 the sub-block in the future field and the sub-block in past field, the sub-block
H21 in past field having the same coordinates as the sub-block in future field;
H22 a set of instructions configured to modulate the first image component based on
H23 the average energy of the differences between a sub-block in the future field
H24 and a prediction of the sub-block in a past field; and
H25 a set of instructions configured to modulate the first image component based on
H26 the average vertical image difficulty of the sub-block in the future field and
H27 the sub-block in past field, the sub-block in past field having the same
H28 coordinates as the sub-block in future field.

1 51. The computer program product as recited in claim 49, further comprising:
2 a set of instructions configured to predict a block based upon a first set of motion
3 information; and
4 a set of instructions configured to predict a sub-block based on the first set of motion
5 information.

1 52. The computer program product as recited in claim 48, further comprising:
2 a set of instructions configured to compute the average energy ("aed0") of the
3 difference between a block in a first field and a block in a second field, the
4 block in the first field having a first set of coordinates, the block in the second
5 field having a second set of coordinates, wherein the first set of coordinates
6 and the second set of coordinates are substantially equal; and
7 a set of instructions configured to modulate the first image component based on the
8 average energy of the difference between the block in the first field and the
9 block in the second field.

1 53. The computer program product as recited in claim 48, further comprising:
2 a set of instructions configured to modulate the second image component based
3 on an average energy ("aed") of a difference between a block in a future field
4 and a prediction of the block in a past field scaled by an image difficulty of a
5 block ("BAI") in the current field.

1 54. The computer program product as recited in claim 53, further comprising:
2 a set of instructions configured to scale *aed* by BAI to produce a modulation
3 factor (also referred to as Ra); and
4 a set of instructions configured to determine if Ra and *aed* are larger than a threshold
5 value; and,
6 a set of instructions configured, if Ra and *aed* are greater than a threshold value, to
7 modulate the second image component based on an average energy ("aed") of
8 a difference between a block in a future field and a prediction of the block in a
9 past field scaled by an image difficulty of a block ("BAI") in a current field.

10 55. The computer program product as recited in claim 54, further comprising:
11 a set of instructions configured to compute a motion for a block of samples, wherein
12 an interpolated pixel is produced if the motion of a block of samples is less
13 than a threshold value;
14 modulating a first image component;
15 adjusting a second image component; and
16 summing the modulated first image component and the adjusted second image
17 component to produce an interpolated pixel.

1 56. The computer program product as recited in claim 54, further comprising:
2 a set of instructions configured to compute the amount of motion for a block of
3 samples, wherein if the amount of motion for the block of samples is greater
4 than a threshold value, an interpolated pixel is produced;
5 a set of instructions configured to modulate a first image component;
6 a set of instructions configured to adjust a second image component, further
7 comprising:
8 a set of instructions configured to reduce a second image component by a
9 factor, wherein the factor (also referred to as "Rm") is computed by scaling
10 *aed* by *aed0*.

1 57. The computer program product as recited in claim 48, further comprising:
2 a set of instructions configured to modulate the first image component, further
3 comprising:
4 a set of instructions configured to sum an ascending term, including
5 increasing a first modulation factor by a function increasing as the
6 motion of the block increases; and
7 a set of instructions configured to sum a descending term, including:
8 decreasing a second modulation factor by a function decreasing as the
9 motion of the block increases.

1 58. A set-top box for de-interlacing video data from interlaced format to
2 progressive format, comprising:
3 a processor,
4 a memory operably coupled to the processor;

5 means to determine a probability of a first image component of a field, wherein the
6 determination assigns a priority to first image component; and
7 means to determine a probability of a second image component of a field, where the
8 determination assigns a priority to the second image component.

1 59. The set-top box as recited in claim 58, further comprising:
2 means to modulate a first image component to produce a first modulated image
3 component;
4 means to modulate a second image component to produce a second modulated image
5 component;
6 means to sum the first modulated image component and the second modulated image
7 component; and
8 means to produce a progressive frame based on the sum of the first modulated image
9 component and the second modulated image component.

10 60. The set-top box as recited in claim 58, further comprising:
11 means to partition a first field to produce a first block of samples;
12 means to partition a second field to produce a second block of samples;
13 means to determine a first image component for the first block of samples; and
14 means to determine a second image component based on the second block of samples.

15 61. The set-top box as recited in claim 59, further comprising:
16 means to modulate the first image component based on an average energy ("aed") of
17 a difference between a block in a future field and a prediction of the block in a
18 past field scaled by an image difficulty of a block ("BAI") in the current field.

19 62. The set-top box as recited in claim 61, further comprising:
20 means to compute the average energy of the differences between a sub-block in a
21 future field and a prediction of the sub-block in a past field;
22 means to compute the average vertical image difficulty of the sub-block in the
23 future field and the sub-block in past field, the sub-block in past field having
24 the same coordinates as the sub-block in future field;
25 means to modulate the first image component based on the average energy of the

9 differences between a sub-block in the future field and a prediction of the sub-
10 block in a past field; and
11 means to modulate the first image component based on the average vertical
12 image difficulty of the sub-block in the future field and the sub-block in past
13 field, the sub-block in past field having the same coordinates as the sub-block
14 in future field.

1 63. The set-top box as recited in claim 61, further comprising:
2 means to predict a block based upon a first set of motion information; and
3 means to predict a sub-block based on the first set of motion information.

1 64. The set-top box as recited in claim 60, further comprising:
2 means to compute the average energy (also referred to as *aed0*) of the difference
3 between a block in a future field and a block in a past field, the block in the
4 future field having a first set of coordinates, the block in the past field having a
5 second set of coordinates, wherein the first set of coordinates and the second
6 set of coordinates are substantially equal; and
7 means to modulate the first image component based on the average energy of the
8 difference between the block in the future field and the block in the past field.

1 65. The set-top box as recited in claim 60, further comprising:
2 means to modulate the second image component based an average energy ("aed") of
3 a difference between a block in a future field and a prediction of the block in a
4 past field scaled by an image difficulty of a block ("BAI") in the current field.

1 66. The method of claim 62, further comprising:
2 means to scale *aed* by BAI to produce a modulation factor (also referred to as *Ra*);
3 and
4 means to determine if *Ra* and *aed* are larger than a threshold value, and if *Ra* and *aed*
5 are larger than the threshold value, modulate a second image component based
6 on an average energy ("aed") of a difference between a block in a future field
7 and a prediction of the block in a past field scaled by an image difficulty of a
8 block ("BAI") in the current field.

1 67. The set-top box as recited in claim 66, further comprising:
2 means to compute a motion for a block of samples, wherein an interpolated pixel is
3 produced if the motion of a block of samples is less than a threshold value;
4 means to modulate a first image component;
5 means to adjust the second image component; and
6 means to sum the modulated first image component and the adjusted second image
7 component to produce an interpolated pixel.

1 68. The set-top box as recited in claim 66, further comprising:
2 means to compute the amount of motion for a block of samples, wherein if the
3 amount of motion for the block of samples is greater than a threshold value, an
4 interpolated pixel is produced;
5 means to modulate a first image component;
6 means to adjust a second image component, further comprising:
7 means to reduce the second image component by a factor, wherein the factor
8 (also referred to as "Rm") is computed by scaling *aed* by *aed0*.

1 69. The set-top box as recited in claim 60, further comprising:
2 means to modulate the first image component, further comprising:
3 means to sum an ascending term, comprising:
4 means to increase a first modulation factor by a function increasing as
5 the motion of the block increases; and
6 means to sum a descending term, comprising:
7 decreasing a second modulation factor by a function decreasing as the
8 motion of the block increases.